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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This ZIM-SCI study guide presents activities and experiments in a unit focusing on the principles of force, support, and action in living things. Major areas investigated include: purpose of skeletons in living things; three main forms of support in plants; three main types of skeletons in animals; the ways in which bones are adapted according to the medium in which an animal lives; and the method by which stability is maintained in four-legged animals (with reference to the center of mass). Other areas investigated include limbs as "animal machines" (muscles which exert a force on a bone which acts as a lever), muscle action, and the protective function of various parts of the skeleton. Information is provided throughout the unit to help students understand the scientific concepts behind the activities and experiments. (JN)

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ZIM-SCI

ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

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STUDY GUIDE UNIT H2

Forces in Living Things

SE 043854

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

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ZIM-SCI

ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

GENERAL SCIENCE

STUDENTS: Please read this carefully. It will help you.

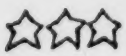
How you will study

This Study Guide comes to you with a kit of apparatus. Both things are part of a study programme leading you to an understanding of aspects of science. In this course you will be carrying out experiments. The Study Guide will help you to understand the scientific principles behind the experiments.

Your work should be done as you are instructed, either by the teacher or the Study Guide.

To help you to see quickly what you must do, the Study Guide uses these symbols:

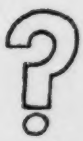
for "Read and revise your notes and Study Guide"



for "Take note of an important point that you should learn"

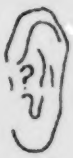
for "Summary. This is to help you to go over what you have learned"

for "Experiment"
When you see this sign, read the instructions carefully from beginning to end before you start to do the experiment.



for "How much do you know?"
This is for you, to help you to test whether you are remembering what is important.

for "Written work"
This is when you must answer questions in writing.



for "Listen to the teacher and do exactly what the teacher tells you to do"

for "Activity"
This symbol will appear whenever you are asked to do something without your apparatus.

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Aims of this Unit

At the end of this unit you should be able to:

Recognise the need for support systems in plants and animals.

Identify the three methods plants use to support themselves.

Identify the three main methods animals use to support themselves.

State three functions of a skeleton.

State the differences in the bones of birds, fish and vertebrates living on land.

Describe how to find the centre of massof an animal and how some maintain stablility.

Describe why pairs of antagonistic muscles are needed for movement and name one pair.

Name and describe 2 important types of joints in mammals.

Show where friction is a disadvantage, and where it is an advantage in the movement of animals.

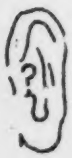
Identify the protective function of the various skeletons.

Unit H_2

In Unit H_1 you learned something about forces. What are the effects of forces on living things?

There is one force which affects all living things - that is the force of gravity.

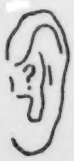
Very light, small organisms are not greatly affected by it, but larger ones have to counteract the constant downward force of gravity.



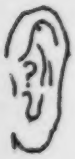
Can you think of some examples of how gravity affects big and small animals?

If living things were soft blobs of jelly, they would lie on the ground like useless heaps. Why do they need to be up off the ground?

1. Plants need to hold out their leaves to obtain sunlight, and exchange gases.
2. Animals have to move about to catch their food and so must reduce another opposing force - that of friction between its own area of surface and the ground.



In order to overcome the various forces living things have developed several ways of holding themselves up and these are called SUPPORT systems. You will already be able to think of some of them yourselves if you think about Unit A2!



Plant Support Systems

Let us look at plants first. Do you remember the model you made of a plant cell in Unit E1? Discuss this model again with your teacher.

Experiment 1

Comparing hard and soft stems.

You will need:-

2 soft plants

a hard twig

a handlens

plastic bag

scalpel

thread

Put one soft plant in a plastic bag.

Tie it closed and leave it in the sun near where you picked it.

Take the other soft stem and try to squeeze it between your thumbnails.

Do the same to the twig. Which is the strongest?

Cut across the soft stem and the hard stem (twig).

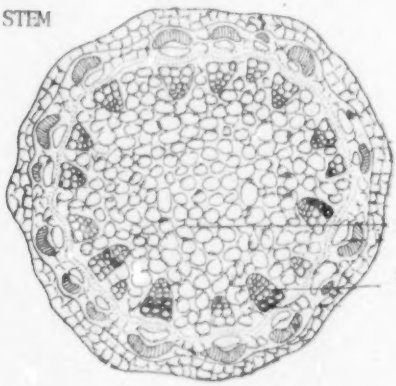
Look at the cut ends using your hand lens. What differences can you see?

Some plants lay down wood. They strenghthen some of their cells by filling them with a hard substance.

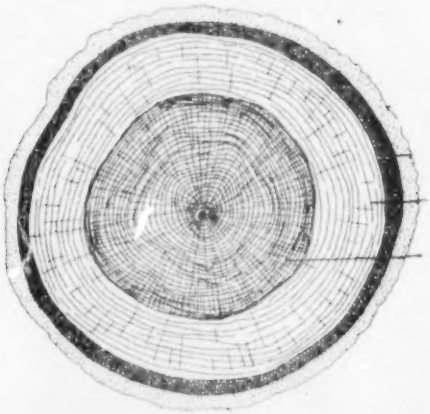
The substance laid down to form wood is called LIGNIN.

Look at these diagrams which show the cut end of a soft stem and one of a hard woody stem.

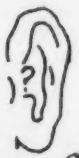
SOFT STEM



HARD WOODY STEM



Now fetch the plant in the plastic bag and compare with the other plants still in the ground. Examine the inside of the plastic bag carefully. Can you see anything which might explain the difference between the plants which are still in the ground and the one in your bag?

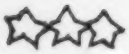


Discuss your thoughts with your teacher.

Now do Exercise 1

Here are some new words for you:

When a plant has lost so much water that it wilts, biologists say its cells have become FLACCID



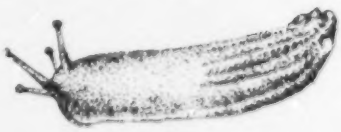
If you water wilted plants so that they recover and become strong and self supporting again their flaccid cells become TURGID.

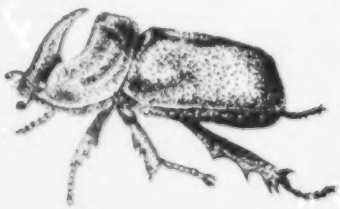
Animal Support Systems

In Unit A2 you learnt of some ways in which animals are supported.

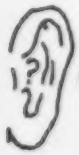
Can you remember how you classified these animals according to their support systems?

Discuss this with your teacher. Here are some pictures to provide clues.





Let us look now at how some of these systems do their jobs. Some animals have no hard skeleton at all. Have you ever seen a dead earthworm lying on the ground? It is quite flat and flaccid. What has happened to it? Do you see any resemblance between a worm and a seedling? Can water support some animals? Discuss this question with your teacher.



Activity 1

You will need:-

a funnel

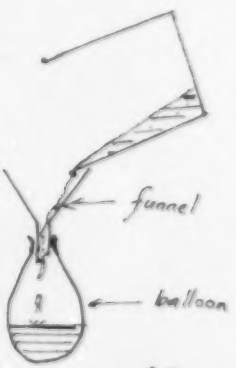
some water

a tin

a long balloon

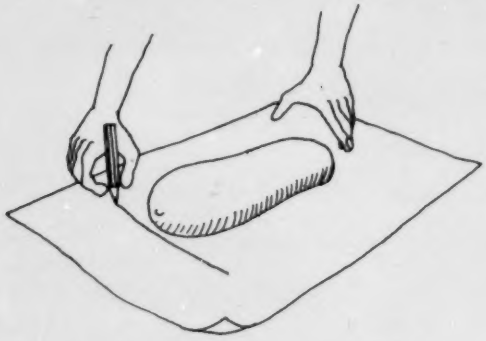
paper and chalk

some thread



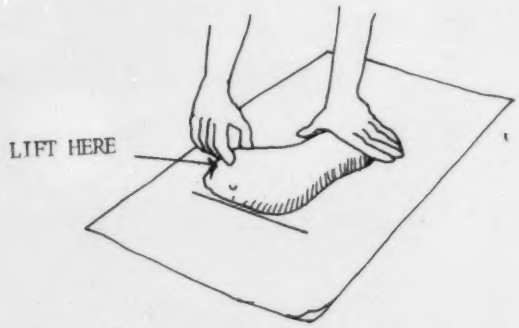
First blow up your balloon fully to stretch it, then let out the air. Fill the balloon with water (using a funnel, as in the diagram) and tie the end. Pretend the rubber balloon is the skin of the worm. Does the water give the balloon a firm shape? Wrap your hands around one end and squeeze it. What happens to the other end? What does this suggest to you?

Now place the balloon on a sheet of paper on your desk. Mark a line at the blunt end of the balloon with a piece of chalk.

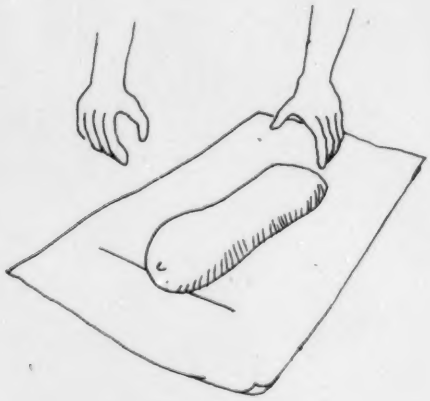


Now place your right hand on half of the balloon as in the diagram and squeeze it down.

Lift up the other end, then hold it down again with your left hand while you lift up your right hand. Repeat this several times.



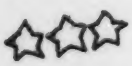
Note the position of the blunt end of the balloon now.



Perhaps your teacher will have a worm for you to watch . Use your hand lens to observe carefully how its shape is supported, and how it moves across the desk. Compare your observations with what you found out using the balloon model.

Write up your conclusions on how a worm moves in Exercise 2.

Worms, slugs, etc. use water, held in by their elastic skin as their means of support. This system is called HYDROSTATIC SKELETON.



Many invertebrates have another form of support. Remember the beetle skeletons you found, and the millipede rings?

Activity 2

Making a Model of an Insect Skeleton

You will need:-

flour

water

a round balloon

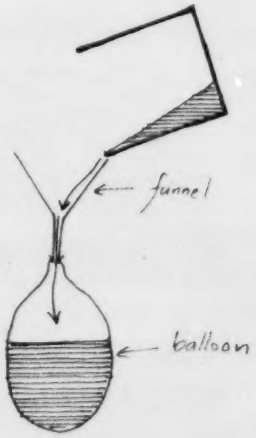
thread

old newspaper

your tunnel

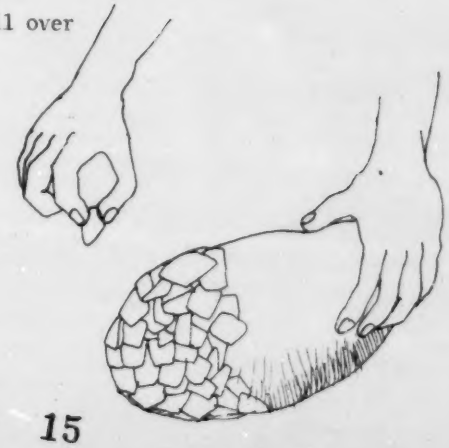
large boiling tin

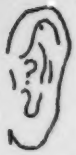
First blow up your balloon and let out the air, then working over the baby bath, fill the balloon with water as in the diagram.



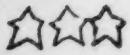
Make a flour and water paste.

Glue the pieces of paper all over the balloon in many layers and allow to dry.





In the next lesson untie your balloon and let out the water (carefully so as not to get the paper wet).
What is left? Discuss this with your teacher.
The paper frame represents the form of support used by many invertebrates - crabs, beetles, spiders. It is called an EXOSKELETON.



The advantage of an exoskeleton is that the animal is more protected and does not dry out so easily, so that it can live above ground or in dry soil.
What can you see as the disadvantages of such a skeleton?
Try blowing up the balloon again inside the paper frame.
Can you get the shape any bigger?
A big disadvantage of an exoskeleton is that the animal is confined inside it and cannot grow.

The ways in which animals with exoskeletons grow.

How do invertebrates overcome this disadvantage?
There are two ways.
Think back on the life cycles you studied.
Some animals go through different stages of development - egg, larva, pupae and then adult. The larval stage has a soft stretchy skin and the animal has its greatest growth at this stage. The hard case of the pupa protects it while the adult stage is forming. When it bursts out of the pupa case, the adult insect is fully grown. Its covering is a soft material called CHITIN which hardens in the air. The insect does not usually grow after this stage, e.g. (fly). Other insects emerge from the egg as an incomplete minature adult. An example of this type of insect is the cockroach. It is not exactly like its parent, but has its legs, and body segments

present. As it grows inside its skeleton, the pressure of the enlarging body contents eventually crack the skeleton. It climbs out, puffs itself up to a bigger size quickly, and like the fly adult, the layer of soft chitin then hardens up to form a new bigger skeleton. This is called MOULTING.

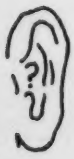
Now do:-

Exercise 3

Looking at Vertebrates

Now you can see the advantages of having an endoskeleton such as those of the Vertebrates - fish, mammals, birds, reptiles. The flesh is outside the frame and the skin can stretch and grow as the flesh does. How does the skeleton grow?

The skeleton of a young embryo is made of a substance called CARTILAGE. This is not as strong as bone. However it contains cells which grow and enlarge the bones as the animal gets bigger. To strengthen the skeleton these cells become filled with minerals, rather like plant cells get filled up with wood (lignin). When an animal is adult the cartilage is almost entirely replaced by strong bone.



Your teacher will have some of this soft skeleton material to show in the breast bone of a chicken. In an old fowl it would be hard.

You yourself have some cartilage inside of you.
You can feel it in your ear, at the tip of your nose, and around your wind pipe.

The importance of diet

You can see nowwhy minerals are necessary to build skeletons as well as protein tissues.
Calcium is the mineral used in the greatest quantity to build bones.
It is not taken directly from a lump of calcium, but is present in some foods in the form in which our body needs it.
One very good source of calcium is milk. This is why it is very important for children to have milk during the years while their bones are growing and becoming hard.
Fresh fruit and vegetables are also necessary because they contain other important minerals - showing again the need for a balanced diet.
Small children should not carry heavy burdens, as their bones may be bent out of their proper shape.

Activity 3

Comparing the bones in the support systems for animals with different life styles.
Your teacher will give you some bones. The one will probably be from a mammal (cow or goat) one from a bird (chicken) and one from a fish.

Examine these carefully while thinking about the way these different animals live. Can you see any differences which would fit in with their life styles?

Discuss this with each other then fill in the table which your teacher will put on the board.

You can understand why a bird has light bones, because it has to fly.

Why does a fish have such a light skeleton?

Find out for yourself in Experiment 2.

Experiment 2

To find out why fish have skeletons with very little mass.

You will need

a forcemeter

string

tin of water

5g masses

Attach four 5g masses to your forcemeter. Imagine this is the mass of a fish you have caught.

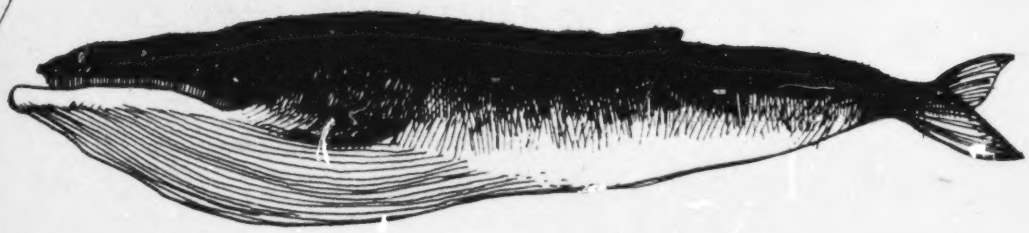
Note the reading on your meter over the water and lower the masses into the water until they are just covered. Watch the forcemeter as you do so. What do you notice?

What does this tell you about the force of gravity on water animals?

Does this also explain why the largest animals in the world, the whales, live in the sea? Some whales are many times more massive than elephants.

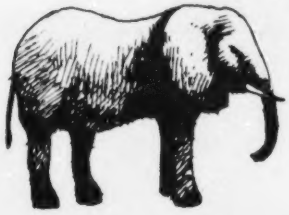
Does this also tell you why a hippo spends as much time as it can under water?

Answer these questions in Exercise 4



WHALE

ELEPHANT



An Elephant dare not lie down on its side, or the weight of its frame, leg and ribs would crush its lungs.

You may have noticed that the chicken leg bone is hollow. The leg bones of mammals too are hollow - have you seen the cut bone from the shin of a cow?

bone

Leg bones need to support the weight of the animals body off the ground. Would it not be as strong to have a thinner solid bone. Why are these bones hollow?

Activity 4

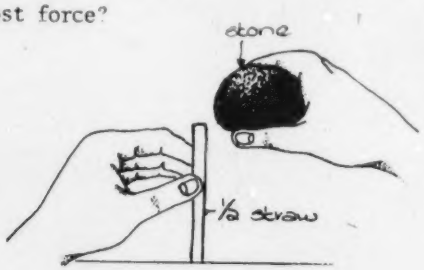
You will need ½ a straw, a shoe or stone, scissors.

Cut your ½ straw into 2 pieces.

Squeeze one half flat by pulling it through your fingers.

Do not bend it.

Hold each straw upright on the floor in turn and hammer down on it with your shoe heel or a stone. Which straw can withstand the most force?



Does this activity explain why supporting bones are hollow? Discuss this with your teacher.

Another function of a skeleton

The skeleton of an animal is useful for support and giving it its usual shape. However it is important for something else too.

Find out what this use is in the next activity

Activity 5

You will need

Your burner stand.

Place the stand the right way up on your desk.

Tap a corner of the top triangle. Now push down on it.

What happens?

Turn the burner stand upside down. Again tap and press the corner of the upper triangle. What happens this time?

One way up the burner stand is STABLE that is, it does not easily fall over. The other way up, the stand falls over easily and is not stable We say it is UNSTABLE

As well as support and shape a skeleton has to provide STABILITY for an animal. This becomes more of a problem when an animal is lifted off the ground, than in an animal such as a lizard or earth worm which is mostly resting on the ground.

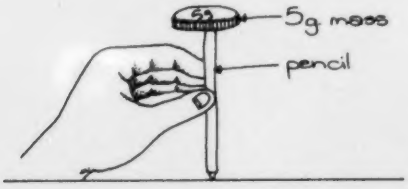
Every object has a centre of balance. This is generally the middle of its mass.

The centre of balance is quite easy to find in an object of a regular shape.

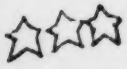
Try this with a 5g mass.

Activity 6

You will need 5g mass and a pencil. Hold your pencil vertical with its point downwards. Try to balance the mass on top of the pencil.



In which position does it balance best?



The CENTRE OF MASS of any body is the point within the animal where the most mass is concentrated.

With objects of odd shapes it is not so easy to find the centre of mass (some times called the centre of gravity).

Here is a way in which it can be done.

You will need:-

A sheet of paper with

2 animal pictures

some thread

a paper clip

a mounted needle

a box

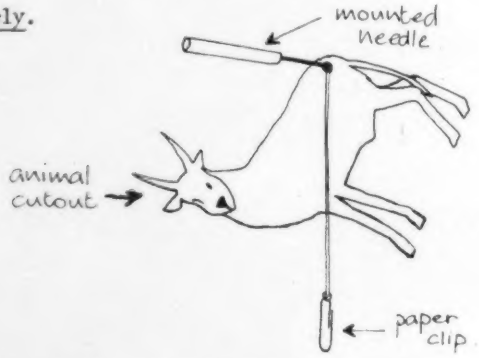
First cut out an animal shape.

Tie a paper clip to the end of your piece of thread.

Tie the other end to the mounted needle.

Push the end of the needle through the head end of an animal shape, making a small hole.

Pin the shape and thread to your box, allowing both to swing freely.



Now draw a line right down the vertical line next to the string.

Remove the needle, and change the point from which you hang the shape - to another part of the animal's body.

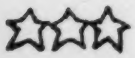
Draw another line.

Where the 2 lines meet is the centre of mass.

Remember however, this is only a "slice through an animal shape"

Repeat with the other animal shape.

Are the centres of mass in the same part of the animals?



The pull of gravity is greatest on the centre of mass.

How does an animal whose body is held up off the ground maintain its stability? Make a model to find out.

Activity 7

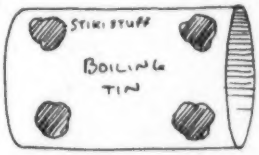
You will need:-

Some sticky stuff or clay

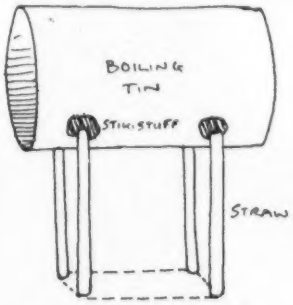
Your boiling tin to act as an animal body

straws (to act as legs)

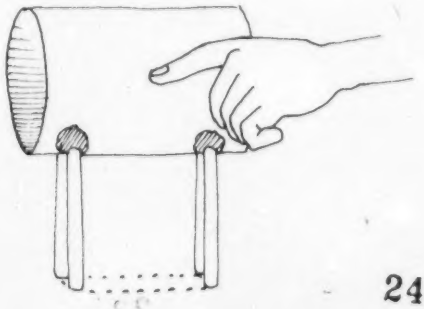
Cut each straw in half and fix the 4 pieces to the boiling tin(as shown in the diagram)with clay or stikistuff.



Place the model on a piece of paper. The straws should be vertical, supporting the tin Draw lines to connect the 4 ends of the straw as in the diagram.



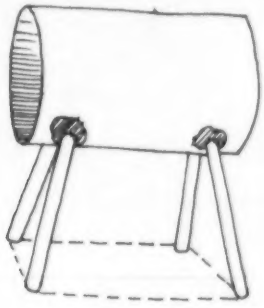
Now give the tin a gentle push. Does it tip over?



Move the ends of the straws apart.

Draw lines to connect the straws again.

The area inside the lines is called the "base".



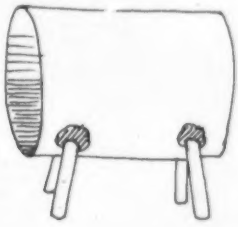
Try tipping the tin over again. Does it tip more easily?

Repeat with the ends of the straws close together.

Which arrangement of the legs is the most stable?

Remove the straws. Cut 2 half straws in half again so that you have 4 quarter straws.

Repea your stability tests using the shorter "legs".



Which animal has greater stability, ones with shorter legs or ones with long legs?

What are the advantages and disadvantages of (a) long (b) short legs?

Discuss this with your teacher.

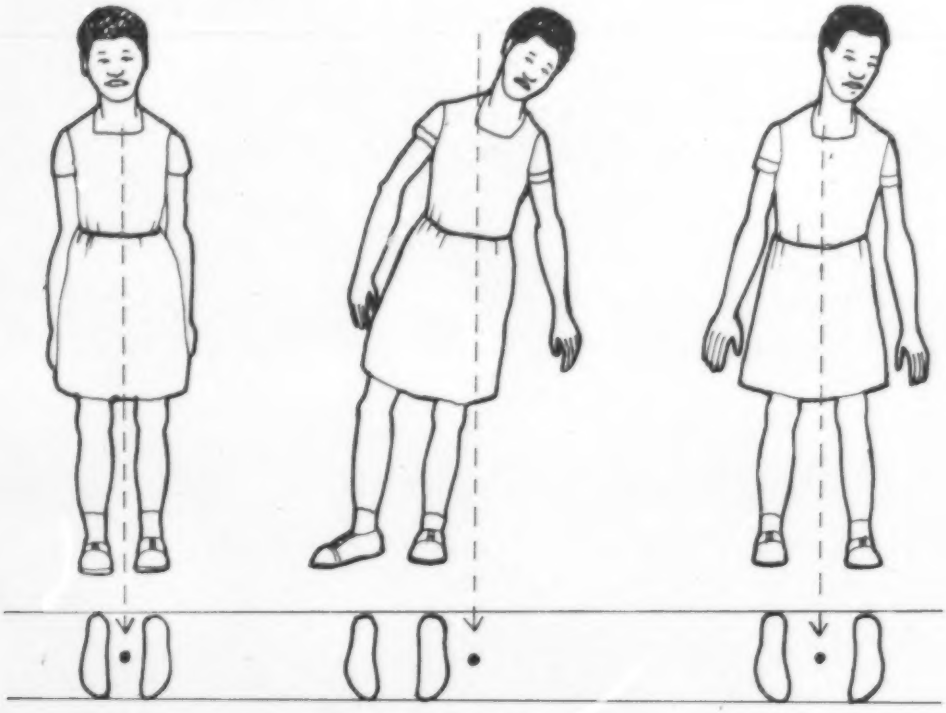
How do you think a fish remains stable?

What happens when your centre of mass is changed?

Activity 8

Stand up, with your feet together. Your partner should give you a push, either from the back or the side. What did you do?

When your centre of mass is pushed over from its stable position you become unstable. You have to move your legs, to change the "base"so that your centre of mass is over this base and you become stable again.



Activity 9

2 pupils will stand against the wall with their heels and heads touching the wall. A chair will be placed in front of each of them. They must bend forward and try to pick it up. What happens?

Exercise 5

Write up the results of this exercise and your explanation for it.

Activity 10

Stand up and walk slowly forward. What is happening as you walk?

Try to work this out and discuss your ideas with your teacher.

When an animal starts to walk it is temporarily unbalanced, or unstable. Stability must be quickly restored again. This process is repeated with each step you take.

WALKING AND FRICTIONAL FORCES

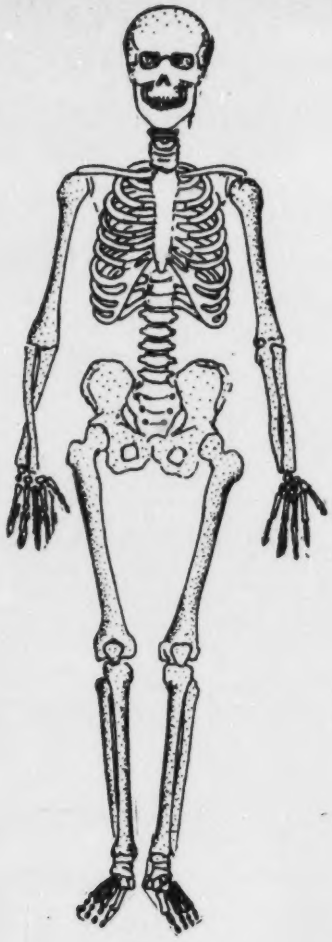
The force of friction acting between the two surfaces involved is walking - the ground, and the feet, give grip. It would be difficult to walk on a highly polished floor, or a slippery road. A little friction is useful!

THE FORCES INVOLVED IN MOVEMENT

As well as providing support and stability, the skeleton serves another purpose - that of helping an animal to move. How does the skeleton which is so stiff help in movement? Look at these pictures of skeletons.

You will see that they are in many parts.

The beetle has 3 parts to its body, and many parts to its legs. There are very many bones in the human skeleton. Look at the number of vertebrae in the back bone alone! This means that the head can turn, and the body can bend or twist



Where bones meet and move on each other a JOINT is formed.

You have joints at your elbow, knee, shoulder and hip.

Can you think of any other joints to tell the class about?

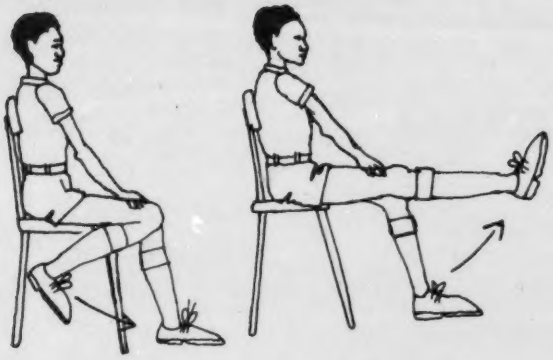
Do all joints behave (work) in the same way?

Think about your joints while doing the next activity.

Activity 11

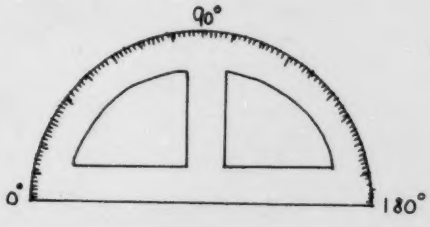
While sitting down lift your foot from the ground by straightening your leg at the knee, then bend your leg back again.

How much can your leg move at the knee?



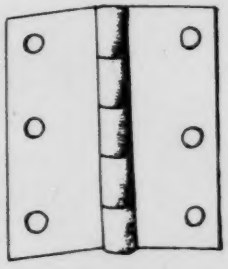
Swing your leg sideways. While you do this grip your thigh with your hand. This shows that the sideways movement does not take place at the knee.

Straighten your arm, then bend it at the elbow. How far can it move?



It can move through nearly 180°.

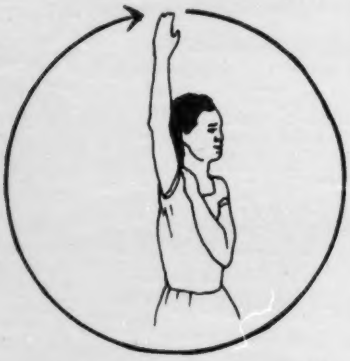
It was a little like opening and shutting a door wasn't it? Because it is like the hinge action of a door, this type of joint is called a HINGE JOINT.

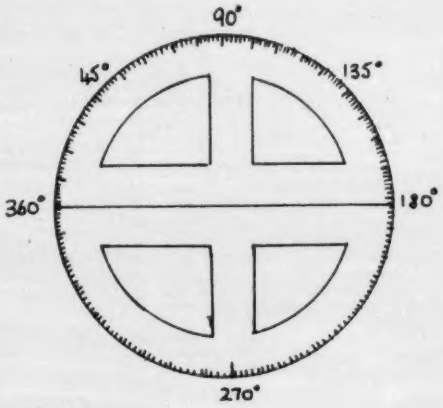


Now stand up and swing your arm from the shoulder.

How much can you move your arm at this joint?

You can swing your arm in many directions and round and round like a wind mill.





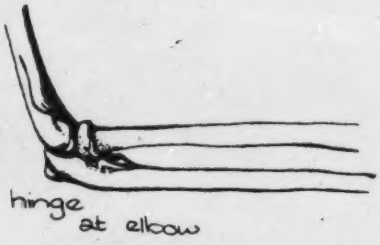
(Try moving your leg from the hip in the same way.)

The joints between your shoulder and arm and hip and leg are very special. The top of the limb bone has a "ball" shaped end. The bones in your shoulder and hip have a rounded hole called a socket. This is like a "cup" into which the ball end fits. It is called a BALL AND SOCKET joint.

You can make a model of this BALL and SOCKET joint.

Clench your left hand into a fist. This represents the ball. Cup your right hand over it. This represents the socket. If you hold your left wrist stiffly you will find you can move your left arm around freely with the "ball" in its "socket".

Here are some pictures of the bones involved in a hinge joint and a ball and socket joint.



Exercise 6

In your books make a drawing of the bones in:-

a) a ball and socket joint

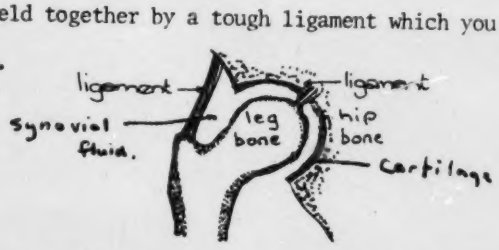
b) a hinge joint

You will learn more about some other types of joints in a later unit.

WHAT MAKES UP A JOINT?

At each joint :-

The bones are held together by a tough ligament which you can see in this diagram.

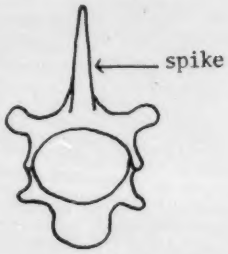


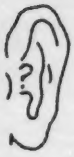
The bones are also connected by elastic tissues called MUSCLES.

At either end of a muscle is a strong TENDON.

The tendons join the muscle to the bones at certain points

Here is a picture of a vertebra. It is a bone from the vertebral column or back bone. It has a long spike which sticks out. Strong muscles attached to the bony spikes of the vertebral column enable you to lift things, twist your body or turn your head.





Where 2 surfaces rub together a frictional force is usually present.

Discuss with your teacher what you learnt in H_1 about the reducing frictional forces.

At joints the friction force could cause pain, so the friction is reduced in two ways:

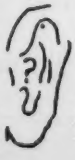
1. A special liquid is present at every joint to act as a lubricant. Each joint works inside a sealed bag containing the lubricating liquid.

   This liquid is called SYNOVIAL FLUID

2. The parts of the bone which meet each other are very smooth - a special hard smooth substance covers them.

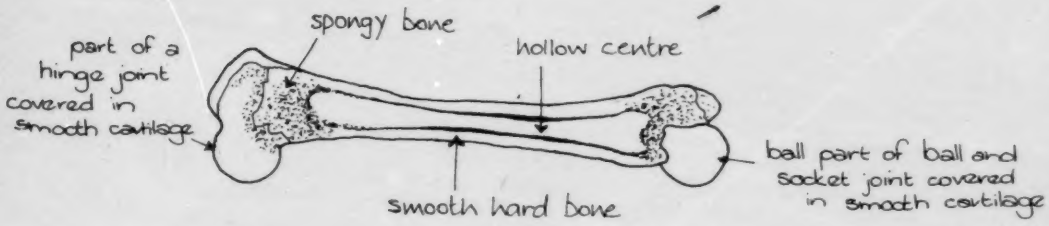
   This is cartilage - like that you have already seen

   This helps the bones to slide over each other during movement.



Your teacher will pass around a long leg bone from a chicken for you to examine the smooth covering at each joint end.

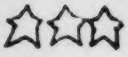
A diagram of one limb bone of a mammal which has been cut open length ways.


spongy bone
hollow centre
part of a hinge joint covered in smooth cartilage
ball part of ball and socket joint covered in smooth cartilage
smooth hard bone

Activity 12

Feeling how muscles act.

Your teacher will give you a sponge. The sponge can be squeezed to contract or become smaller. When you release it it springs back to its former shape.



A muscle acts in a similar way. Energy is needed to contract it, the same as you had to put energy into squeezing it. A muscle can contract, and return to its relaxed position. It cannot stretch out.

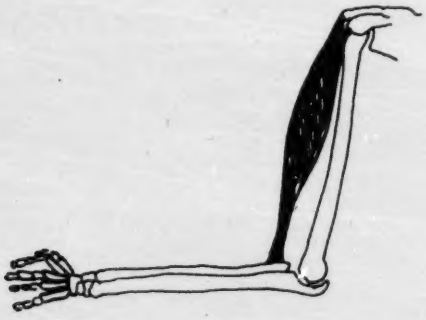
Feel your own muscle contract in Activity 13

Activity 13.

Stretch out your right arm in front of you, palm upwards. Place your left hand over your upper arm as in the picture.

Now bend your elbow and raise your right hand. What does your left hand feel?

This muscle which you can feel is called the BICEPS muscle.



Making a model of an arm

Experiment 3 To find out how the muscles in your arm make it move.

For this experiment you will have to work in groups of 4.

You will need:-

2 straws

2 mounted needles

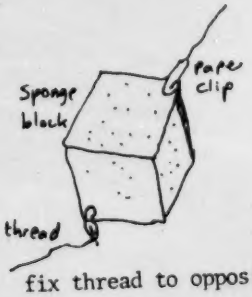
thread

2 sponges 4 paper clips

pins

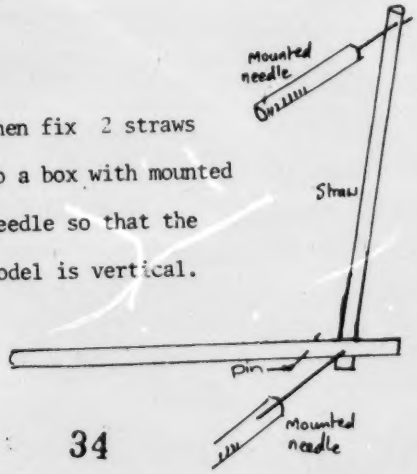
your kitbox

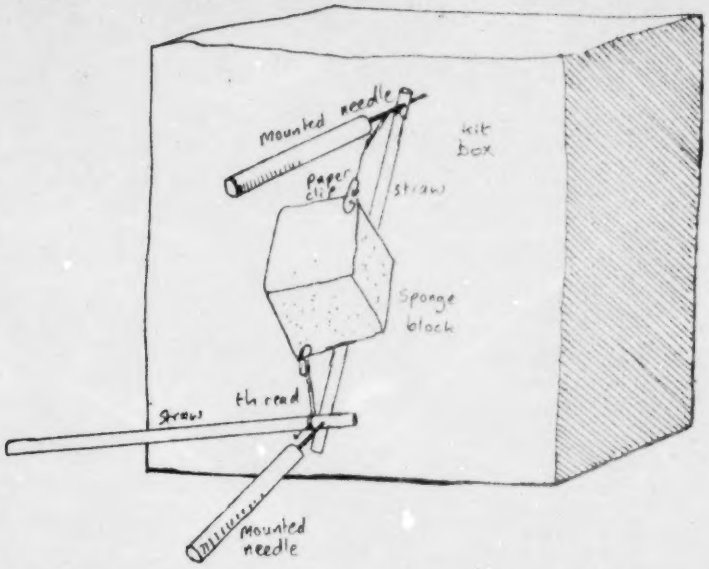
Assemble the model as in the diagram.



fix thread to opposite corners of a sponge , either tie it on, or use 2 paper clips.

Then fix 2 straws to a box with mounted needle so that the model is vertical.

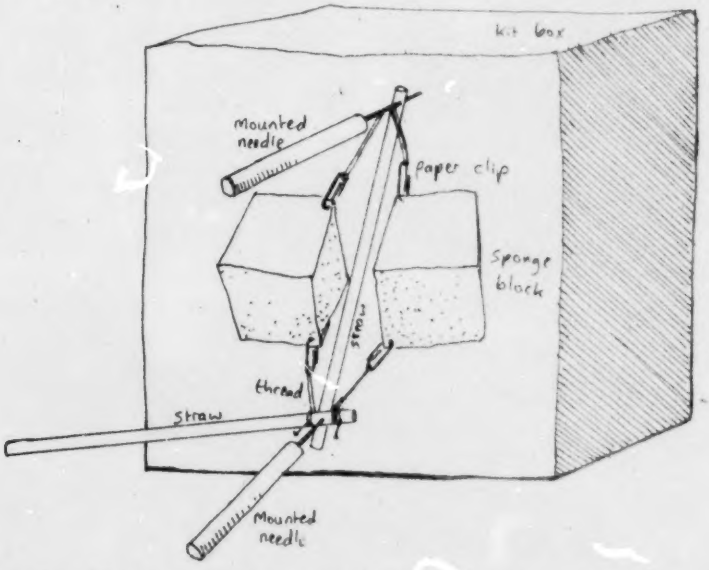




The straws represent the long bones in your arm, and the sponge represents your biceps muscle.

Squeeze the sponge. What happens?

But what would happen if you wished to force your arm out straight, as you would need to do if you pushed someone out of your way? Your biceps can only raise your fore-arm, not stretch it out or straighten it.



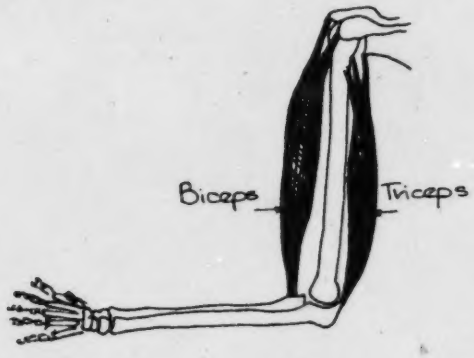
Fix the other sponge in position as in this diagram. It represents another muscle in your arm called the triceps.

Squeeze this sponge. What happens?

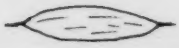
Squeeze first one sponge and then the other.

There is a pair of muscles in your upper arm. These act together in opposite directions to raise or lower the arm, and are known as an ANTAGONISTIC pair.

Look up the word ANTAGONISTIC in the dictionary, does its meaning fit the use of this word?

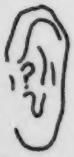


contracted muscle



relaxed muscle

In your daily life (and in the activities of all animals) a great variety of movements and forces are needed. Sometimes the force must be very large for instance if you are lifting a heavy object. Sometimes the forces are very small like moving your little finger! The skeleton and muscle system is built with large muscles where large forces are required and small muscles where only small forces are needed.



Each muscle, bone and joint set behaves like a machine. What kind of machines are they? Discuss this idea with your teacher.

Experiment 4

Lifting a brick using your biceps muscles

You will need:-

some string

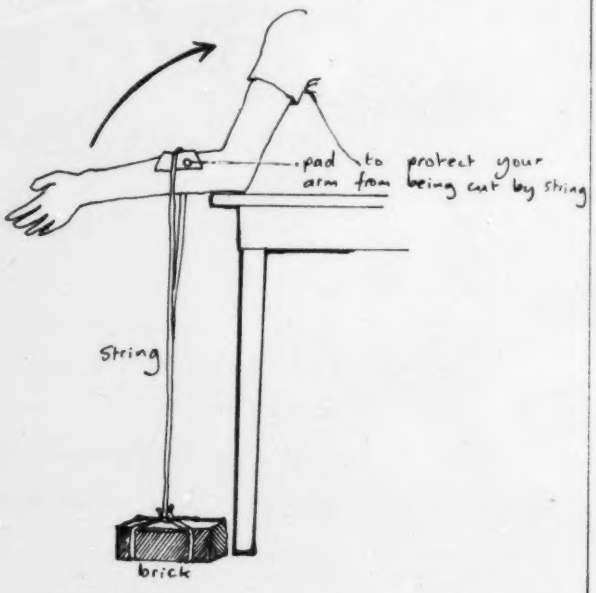
a brick or similar heavy object

a pad made from folded paper

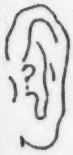
or material

Tie some string around the brick and make a loop so that the brick and loop together will stretch from the floor to the height of your desk.

Now sit with your elbow resting on the edge of your desk as in the diagram. Place the pad halfway along your forearm and slip the loop of string over it. Now try to lift the brick. Is it difficult?



Move the pad to your wrist and slip the string loop over it. Try again to lift the brick. Is it more difficult or easier this time?



Discuss your results with your teacher. Perhaps the next experiment will help explain your findings.

Experiment 5

To investigate the force involved in lifting with the biceps muscles.

You can find out the sort of forces exerted by the biceps muscle if you make a model of your arm.

You will need:-

a straw to represent your forearm

a forcemeter to represent your biceps muscle

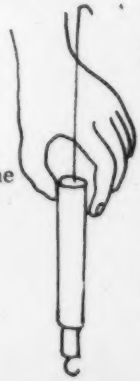
4 pins (to stop the weight slipping off)

a mounted needle to make a pivot and represent the elbow joint

a brick to hold the model in place

Thread your 5g masses on a loop of string.

First, holding your forcemeter as in the diagram, read the unloaded position of the forcemeter on the wooden part. This is your zero.

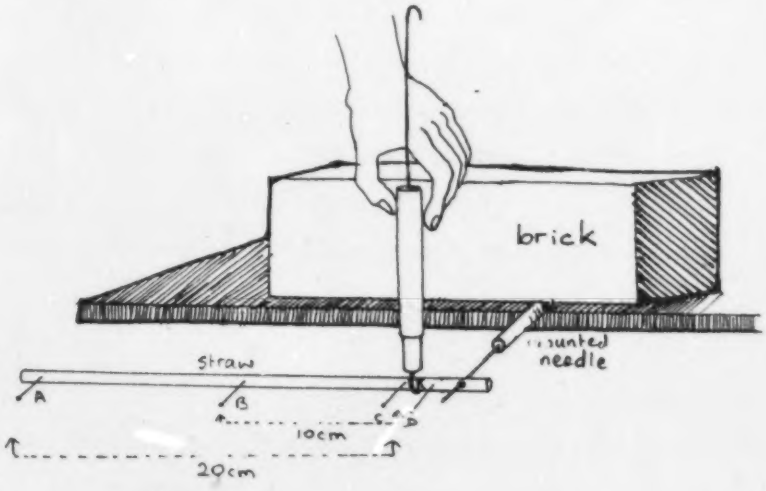


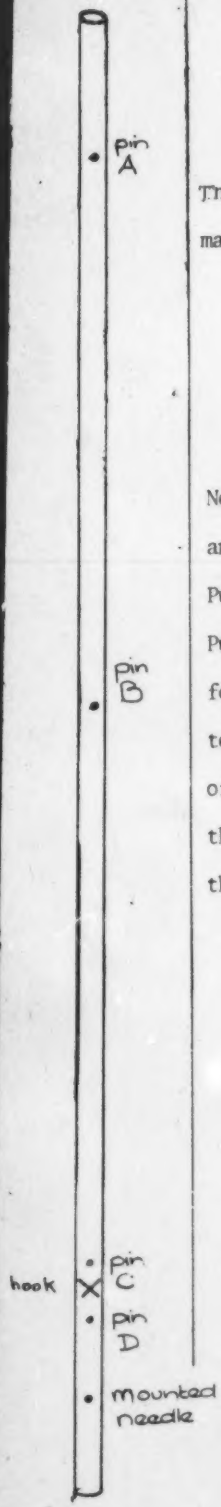
Then slip the 4 x 5g masses on the hook, and read the mark on the forcemeter.

Now lay your straw on the diagram at the edge of this page and assemble your model as follows:-

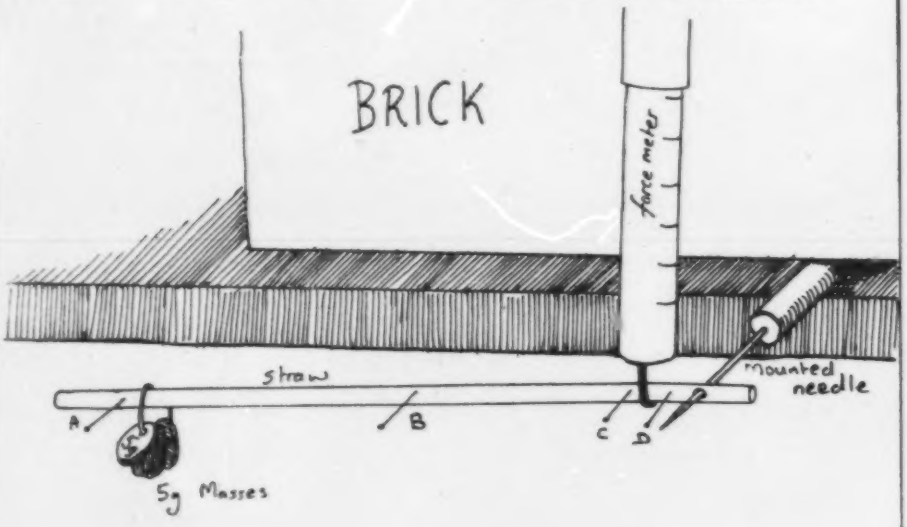
Push in pins at points A,B and C.

Push the end of the straw through the short wire loop of the forcemeter up to the pin at C. Next place another pin at D to keep the forcemeter from slipping. Now push in the point of the mounted needle at E. Then place the wooden handle of the needle on your desk, and hold it down with a brick as in this diagram.

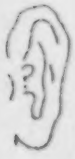




Now slip the string loop of the masses over the pin at B.
(This represents the middle of your forearm.)
Holding the forcemeter by the white tube pull upwards until the straw is horizontal (level). Your partner should read the mark on the wood of the forcemeter to show how far it stretched.



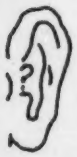
Now move the masses to point A which represents your wrist.
Again pull the forcemeter until the straw is level (horizontal).
Take another reading of the forcemeter.
The readings you took on your forcemeter are in Newtons.
The length of the straw from the forcemeter to A = 20 cm.
The length of the straw from the forcemeter to B = 10 cm.
What do you notice? Make a table of your results.



What can you say about the distance the masses were moved in each case?
Discuss this with your teacher.

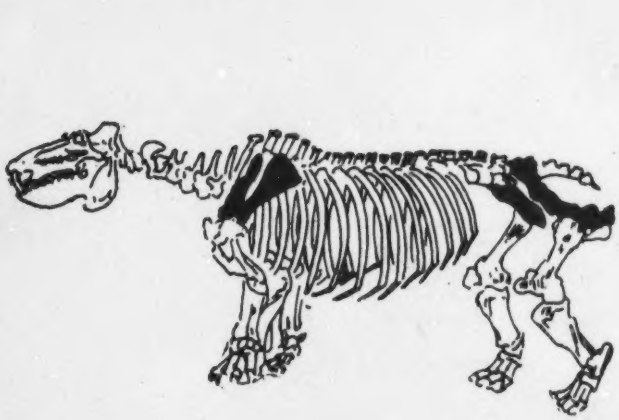
In the legs and feet there are many bones and sets of antagonistic muscles, that in a complicated way lift the body from the ground and move it forward.

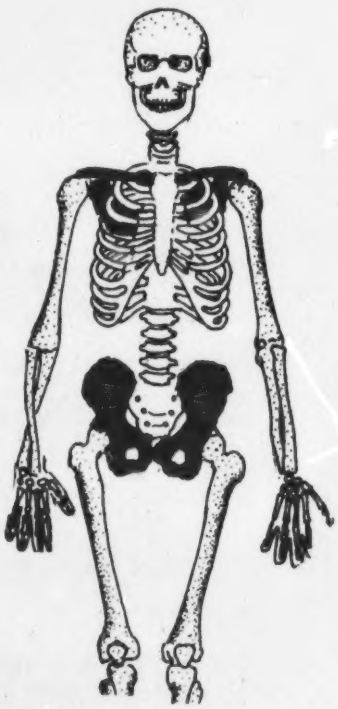
The leg muscles, pulling on the leg bones exert a push or thrust force. This force has to be transferred from the leg to the rest of the body. A specially strong supporting structure is needed to act between the leg bones and the spine. This bone structure is called a GIRDLE. Girdles are present at the hip and shoulder. You can feel your girdles now.



In the human animal the hip girdle is more important than the shoulder girdle. Can you think why?

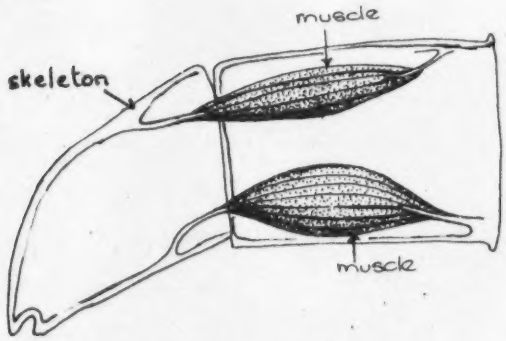
Look at the pictures of the skeletons of a man and a four legged mammal. Compare the relative sizes of their girdles. What do you notice?





How do insects move?

Insects also have sets of antagonistic muscles, and jointed limbs. Of course the difference is that their muscles are inside the skeleton!



The muscles moving an insect claw within the skeleton.

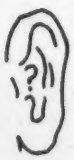
Which muscle lifts the claw up?

Which muscle lowers the claw down?

Protection

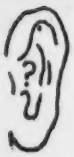
The last function of the skeleton which we will consider is that of protection.

Look again at the picture of a human skeleton. What important organs are protected by the skull?



What other arrangement of bones seems to protect another important set of organs? Look back to the picture of the vertebrae bone and discuss it with your teacher.

The intestines are only protected from the back by the pelvic girdle but our skeletons would be very massive if every organ was surrounded by a bony shield.



You know that a hard exoskeleton gives protection from drying out and damage to many invertebrates. Birds are not as fond of hard beetles as of soft larvae and worms! However, a stiff skeleton all over is heavy and not always desirable. Many insects have parts of their skeleton harder than the rest. Can you think of some examples?

In this unit we have investigated the various ways in which the muscles, bones and joints in an animal's body combine to allow movement. You have learnt that each movement is carried out through a lever system very similar to the machines you studied in H_1.

Now you know why eating energy containing foods is so important. Our 'joint machines' need energy to carry out the work we tell them to do!

You have learnt a little about how the energy is taken into our bodies from the food we eat (Unit G). We will be investigating the way in which this energy reaches the muscles in a later unit.

Now Read and Revise and do
"How much do you know"

How much do you know?

1. The 3 main methods of support used by plants are _____, _____ and _____.
2. A worm has a _____ skeleton.
   A beetle has an ___ skeleton.
   A cow has an ____ skeleton.
3. A wilted plant is said to be _____ If watered it becomes _____ again.
4. Animals raise themselves above the ground to overcome the force of _____.
5. The centre of mass of an object is _____
6. A skeleton gives a body _____ and _____.
7. A skeleton and the muscles help the animal to _ _ and also to keep it_____.
8. In order to _____ _____ a stiff skeleton needs joints.
9. Two important types of joints are the _____ and _____ joint, found at the _____ or _____ and the _____ joint found at the _____ and _____.
10. Joints operate in a bag of _____ fluid and have smooth _____ at the moving surfaces to reduce friction.
11. Limbs are operated by pairs of _____ muscles, for example the _____ and _____ muscles in the arm.
12. The energy put in to contract the muscles comes from _____.

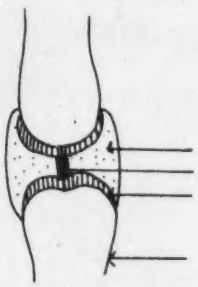
13. A skull protects the _____.
    Ribs and breastbone protect the _____ and _____.
    The _____ protects the lower abdominal organs.

14. Muscles and bones work like _____,
    and make up a sort of " animal _____."

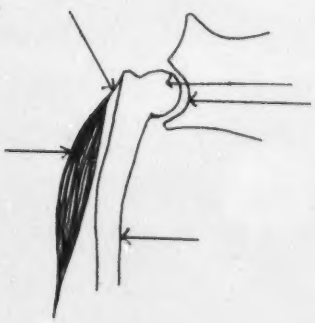
15. A _____ contraction of the biceps muscle raises the hand a _____ way.

Fill in the correct labels on these diagrams:-

A ..... joint at the knee.



A ..... and ..... joint at the shoulder.



Summary of Unit H_2

Plants need support to best obtain light and exchange gases. To this end they use water within stiff cell walls, or lignin filled woody cells.

Soft parts of plants are turgid when well supplied with water, and flaccid if the plant wilts.

Summary of skeletal types

Hydrostatic Skeleton		
Support.	Elastic skin Pressure of internal liquids	Easy growth, not much reduction of friction. Movement by circular & longitudinal muscles acting alternately. Little protection from drying out and damage.
Exoskeleton.	'ard outer covering (chitin)	Rigid and heavy skeleton sometimes reduced over abdomen. It affords protection and firm attachment for limbs. Movement usually by jointed limbs, with antagonistic internal muscles. Growth by moulting, or different stages in a life cycle.

Endoskeleton.	internal frame of bones	Rigid strong internal frame. Protection only given to some organs. Growth by soft cartilage cells, hardening into bone cells with minerals when adult. Movement by using antagonistic muscles and bones as levers.

Animals need skeletons to give shape, support and assist in movement, so that they may obtain food. Friction during movement may be reduced by lifting as much animal surface area as possible off the ground. This function also is performed by the skeleton, which also has to balance the force of gravity on the centre of mass and keeps the animal stable. The lower the centre of mass, the more stable the animal.

Bones

The bones of land animals are strong and heavy , sometimes being hollow to reduce mass.

The bones of fish are light and flexible because the great part of the mass of the fish is supported by water. The fins of the fish give it stability and some movement - not the support given to other vertebrates by limbs.

Bones of birds are very light as it spends much of its time in the air.

Joints

Where bones move on each other a variety of joints occur - e.g. hinge or ball and socket joints. The bones are held together by ligaments and friction is reduced by cartilage and synovial fluid. Muscles are attached by tendons.

Movement

Movement is achieved with bones acting as levers and elastic muscle tissue putting in work by contracting and moving the levers. A short muscle contraction achieves a greater length of movement at the end of the lever.